

CLAIMS

What is claimed is:

1. A communications channel that includes a buffer that receives user data symbols including a plurality of M -bit symbols, comprising:

a seed selector that receives said plurality of M -bit symbols, that selectively removes symbols from a seed set based on Hamming distances between at least two of said M -bit symbols, and that selects a scrambling seed from remaining symbols in said seed set;

a scrambling device that communicates with said seed selector and said data buffer and that generates scrambled user data based on said user data symbols and said scrambling seed.

2. The communications channel of Claim 1 wherein said communications channel is implemented in a data storage system.

3. The communications channel of Claim 1 wherein said seed selector ensures a minimum Hamming weight of 15 percent in said scrambled user data.

4. The communications channel of Claim 1 wherein said seed selector compares first and second user data symbols in said plurality of M -bit symbols.

5. The communications channel of Claim 4 wherein said seed selector removes said first and second user data symbols from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is greater than or equal to three.

6. The communications channel of Claim 4 wherein said seed selector removes said first and second user data symbols from said seed set, and symbols from said seed set that have Hamming distances of one from said first and second user data symbols when a Hamming distance between said first user data symbol and said second user data symbol is equal to two.

7. The communications channel of Claim 4 wherein said seed selector removes said first and second user data symbols from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is equal to one.

8. The communications channel of Claim 4 wherein said seed selector removes said first user data symbol from said seed set, a third user data symbol from said seed set that is adjacent to said second user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

9. The communications channel of Claim 4 wherein said seed selector removes said first user data symbol from said seed set, a third user data symbol from said seed set that is adjacent to said second user data symbol, a fourth user data symbol from said seed set that is adjacent to said third user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

10. The communications channel of Claim 4 wherein said seed selector removes said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, and a second symbol from said seed set that is the one's complement of said second user data symbol from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is greater than or equal to three.

11. The communications channel of Claim 4 wherein said seed selector removes said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a second symbol from said seed set that is the one's complement of said second user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol and said second user data symbol when a Hamming distance between said first user data symbol and said second user data symbol is equal to two.

12. The communications channel of Claim 4 wherein said seed selector removes said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, and a second symbol from said seed set that is the one's complement of said second user data symbol from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is equal to one.

13. The communications channel of Claim 4 wherein said seed selector removes said first user data symbol from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a third user data symbol from said seed set that is adjacent to said second user data symbol, a second symbol from said seed set that is the one's complement of said third user data symbol, and symbols from said seed set that have Hamming distances

of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

14. The communications channel of Claim 4 wherein said seed selector removes said first user data symbol from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a third user data symbol from said seed set that is sequential to said second user data symbol, a second symbol from said seed set that is the one's complement of said third user data symbol, a fourth user data symbol from said seed set that is sequential to said third user data symbol, a third symbol from said seed set that is the one's complement of said fourth user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

15. The communications channel of Claim 1 further comprising:
an error correction coding (ECC) encoder (ENC) that communicates with said scrambling device and said seed selector, wherein said ECC ENC appends at least one of cyclic redundancy check (CRC) code, ECC, and said scrambling seed to said scrambled user data.

16. The communications channel of Claim 1 wherein said scrambling device generates said scrambled user data by determining a bit-wise exclusive-OR (XOR) of said scrambling seed and said user data symbols.

17. A communications channel that includes a buffer that receives user data symbols including a plurality of *M*-bit symbols, comprising:

seed selecting means for receiving said plurality of *M*-bit symbols, for selectively removing symbols from a seed set based on Hamming distances between at least two of said *M*-bit symbols, and for selecting a scrambling seed from remaining symbols in said seed set;

scrambling means that communicates with said seed selecting means and the data buffer for generating scrambled user data based on said user data symbols and said scrambling seed.

18. The communications channel of Claim 17 wherein said communications channel is implemented in a data storage system.

19. The communications channel of Claim 17 wherein said seed selecting means ensures a minimum Hamming weight of 15 percent in said scrambled user data.

20. The communications channel of Claim 17 wherein said seed selecting means compares first and second user data symbols in said plurality of *M*-bit symbols.

21. The communications channel of Claim 20 wherein said seed selecting means removes said first and second user data symbols from said

seed set when a Hamming distance between said first user data symbol and said second user data symbol is greater than or equal to three.

22. The communications channel of Claim 20 wherein said seed selecting means removes said first and second user data symbols from said seed set, and symbols from said seed set that have Hamming distances of one from said first and second user data symbols when a Hamming distance between said first user data symbol and said second user data symbol is equal to two.

23. The communications channel of Claim 20 wherein said seed selecting means removes said first and second user data symbols from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is equal to one.

24. The communications channel of Claim 20 wherein said seed selecting means removes said first user data symbol from said seed set, a third user data symbol from said seed set that is adjacent to said second user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

25. The communications channel of Claim 20 wherein said seed selecting means removes said first user data symbol from said seed set, a third user data symbol from said seed set that is adjacent to said second user data symbol, a fourth user data symbol from said seed set that is adjacent to said third user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

26. The communications channel of Claim 20 wherein said seed selecting means removes said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, and a second symbol from said seed set that is the one's complement of said second user data symbol from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is greater than or equal to three.

27. The communications channel of Claim 20 wherein said seed selecting means removes said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a second symbol from said seed set that is the one's complement of said second user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol and said second user data symbol when a Hamming distance between said first user data symbol and said second user data symbol is equal to two.

28. The communications channel of Claim 20 wherein said seed selecting means removes said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, and a second symbol from said seed set that is the one's complement of said second user data symbol from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is equal to one.

29. The communications channel of Claim 20 wherein said seed selecting means removes said first user data symbol from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a third user data symbol from said seed set that is adjacent to said second user data symbol, a second symbol from said seed set that is the one's complement of said third user data symbol, and symbols from said seed set that

have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

30. The communications channel of Claim 20 wherein said seed selecting means removes said first user data symbol from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a third user data symbol from said seed set that is sequential to said second user data symbol, a second symbol from said seed set that is the one's complement of said third user data symbol, a fourth user data symbol from said seed set that is sequential to said third user data symbol, a third symbol from said seed set that is the one's complement of said fourth user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

31. The communications channel of Claim 17 further comprising:
error correction coding (ECC) means that communicates with said scrambling means and said seed selecting means for appending at least one of cyclic redundancy check (CRC) code, ECC bits, and said scrambling seed to said scrambled user data.

32. The communications channel of Claim 17 wherein said scrambling means generates said scrambled user data by determining a bit-wise exclusive-OR (XOR) of said scrambling seed and said user data symbols.

33. A method for operating a communications channel that includes a buffer that receives user data symbols including a plurality of M -bit symbols, comprising:

receiving said plurality of M -bit symbols;

selectively removing symbols from a seed set based on Hamming distances between at least two of said M -bit symbols;

selecting a scrambling seed from remaining symbols in said seed set;

generating scrambled user data based on said user data symbols and said scrambling seed.

34. The method of Claim 33 wherein said communications channel is implemented in a data storage system.

35. The method of Claim 33 wherein said scrambled user data has a minimum Hamming weight of 15 percent in said scrambled user data.

36. The method of Claim 33 further comprising comparing first and second user data symbols in said plurality of M -bit symbols.

37. The method of Claim 36 further comprising removing said first and second user data symbols from said seed set when a Hamming distance

between said first user data symbol and said second user data symbol is greater than or equal to three.

38. The method of Claim 36 further comprising removing said first and second user data symbols from said seed set, and symbols from said seed set that have Hamming distances of one from said first and second user data symbols when a Hamming distance between said first user data symbol and said second user data symbol is equal to two.

39. The method of Claim 36 further comprising removing said first and second user data symbols from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is equal to one.

40. The method of Claim 36 further comprising removing said first user data symbol from said seed set, a third user data symbol from said seed set that is adjacent to said second user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

41. The method of Claim 36 further comprising removing said first user data symbol from said seed set, a third user data symbol from said seed set that is adjacent to said second user data symbol, a fourth user data symbol from said seed set that is adjacent to said third user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

42. The method of Claim 36 further comprising removing said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, and a second symbol from said seed set that is the one's complement of said second user data symbol from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is greater than or equal to three.

43. The method of Claim 36 further comprising removing said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a second symbol from said seed set that is the one's complement of said second user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol and said second user data symbol when a Hamming distance between said first user data symbol and said second user data symbol is equal to two.

44. The method of Claim 36 further comprising removing said first and second user data symbols from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, and a second symbol from said seed set that is the one's complement of said second user data symbol from said seed set when a Hamming distance between said first user data symbol and said second user data symbol is equal to one.

45. The method of Claim 36 further comprising removing said first user data symbol from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a third user data symbol from said seed set that is adjacent to said second user data symbol, a second symbol from said seed set that is the one's complement of said third user data symbol, and symbols from said seed set that have Hamming distances of one from said

first user data symbol when said first user data symbol is equal to said second user data symbol.

46. The method of Claim 36 further comprising removing said first user data symbol from said seed set, a first symbol from said seed set that is the one's complement of said first user data symbol, a third user data symbol from said seed set that is sequential to said second user data symbol, a second symbol from said seed set that is the one's complement of said third user data symbol, a fourth user data symbol from said seed set that is sequential to said third user data symbol, a third symbol from said seed set that is the one's complement of said fourth user data symbol, and symbols from said seed set that have Hamming distances of one from said first user data symbol when said first user data symbol is equal to said second user data symbol.

47. The method of Claim 33 further comprising appending at least one of cyclic redundancy check (CRC) code, ECC bits, and said scrambling seed to said scrambled user data.

48. The method of Claim 33 further comprising generating said scrambled user data by determining a bit-wise exclusive-OR (XOR) of said scrambling seed and said user data symbols.